LMI Selcom

MEASUREMENT & CONTROL

fingerkg

User's Manual

SLS 7000

Contents

Contents 2
1 General information 3
2 Component description 4
2.1 Sensor description 4
2.2 Accessories 6
2.2.1 Cables 6
2.2.2 SLS Power unit 24 6
2.2.3 Video Camera 9
3 Laser safety 10
3.1 Classification 10
3.2 Warning labels 10
4 Installing 11
4.1 Pin configuration 11
4.2 Cable requirements 12
4.2.1 Cable length 12
4.2.2 Signal leads with demand for twisted pairs 12
4.2.3 Signal leads without demand for twisted pairs 12
4.2.4 Power supply leads 12
4.2.5 Cable screening 12
4.3 Analog output 13
4.3.1 General considerations 13
4.4 Load conditions for analog and invalid outputs 14
4.4.1 Analog output load 14
4.4.2 Optional noise filtering 14
4.4.3 Alternative connections for valid output 15
4.5 Mechanical mounting 16
4.5.1 Sensor head mounting 16
4.5.2 SLS-PPU mounting 17
5 Technical specification 17
5.1 general 17
5.2 Performance specification 17
5.3 Laser beam characteristics 18
6 Hints on correct use 19
7 Communication interfaces 21
7.1 General 21
7.2 Selcom Serial interface 21
7.3 SLS-asynch-1, Protocol 22
8 Ordering and spare parts information 33

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1 General information

The SLS7000 Specular reflective sensor is intended for measuring surfaces ranging from perfect mirrors to semi-specular surfaces such as aluminium, stainless steel and other reflective materials.

The specular reflective triangulation principle provides, as opposed to the more commonly used diffuse reflection triangulation, a principally higher capability for high-resolution data on shiny and reflective materials and surface structures.

The SLS7000 has been designed to further stretch the area of use towards difficult surface structure materials like the cold rolled special steel used in hard disk drive read/write head suspensions.

Resolution in the sub micron range is typically achievable in such applications.

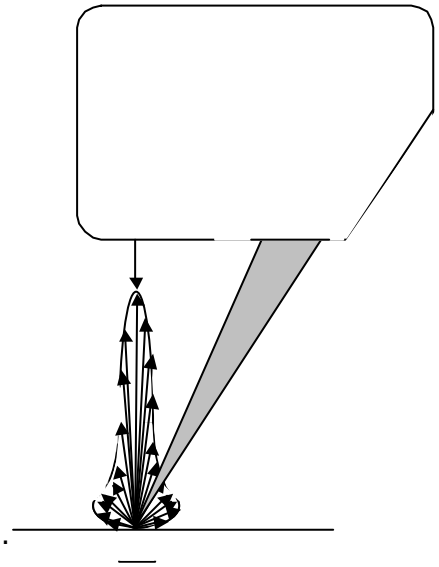


Fig. 1.

The diffuse reflection sensor will only "see" a minor part of the beam reflected from a semi-specular surface.

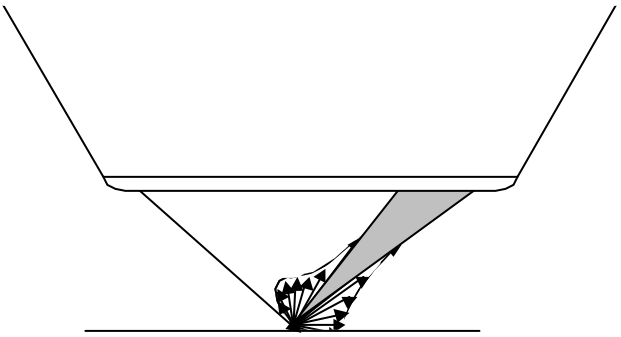


Fig. 2

The specular reflection sensor Picks up a major part of the reflected beam.

The wide triangulation angle and 10-micron sized laser spot further enhances the basic triangulation resolution.

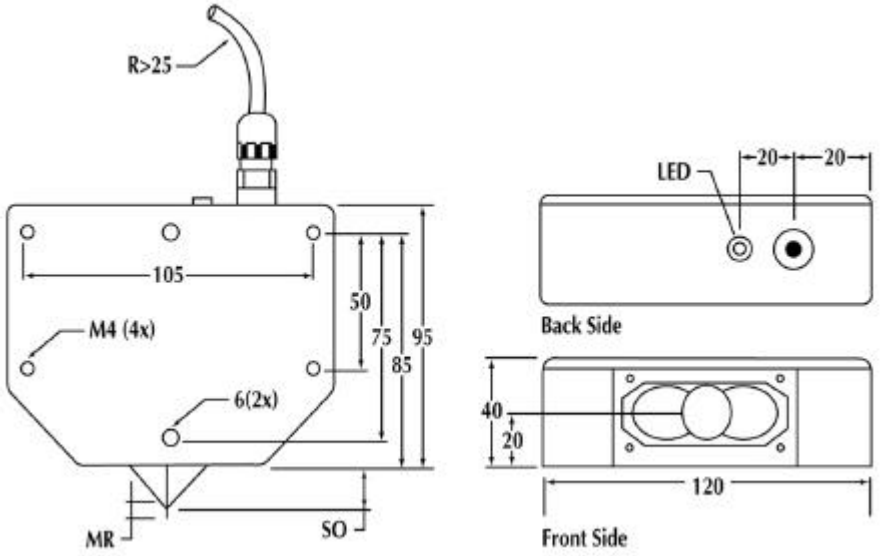
2 Component description

2.1 Sensor description

The basic SLS7000 sensor consists of two parts:

- SLS7000 Sensor head
- SLS-PPU controller

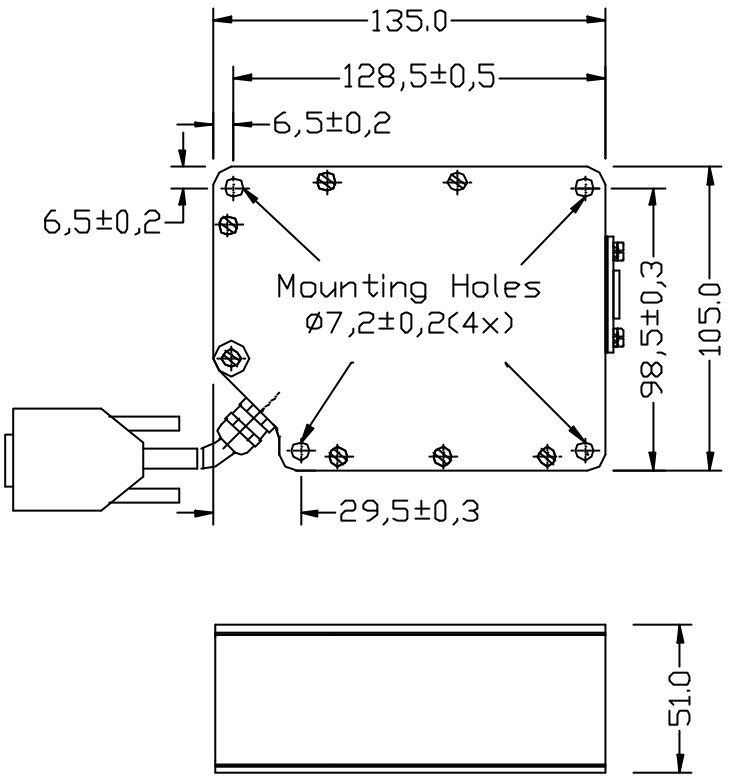
Figure 3. SLS7000 Sensor head



The 3 m sensor cable connects to the SLS-PPU with a high density connector.

A red LED on the sensor top surface indicates sensor power ON.

Figure 4. SLS-PPU controller



The 2 m cable from the SLS-PPU controller connects to the user Power supply/data acquisition equipment via a 15 pin high density D-sub connector.

Two LED's on the top surface of the controller indicates valid data in the measurement range (green LED) or Invalid data/out of range (yellow LED) condition.

A continuous switching between Yellow and Red LED indicates a malfunction in the sensor DSP (Digital Signal Processor)

2.2 Accessories

2.2.1 Cables

To facilitate different installation needs a variety of extension and connection cables are available for use with the sensor stand-alone or in combination with the SLS Power Unit.

Contact LMI Selcom or your local representative for more information.

2.2.2 SLS Power unit 24

The SLS Power unit 24 can supply one or two SLS7000 sensor sensors.
The customer must provide a power cable of suitable length, fitting the power receptacle.

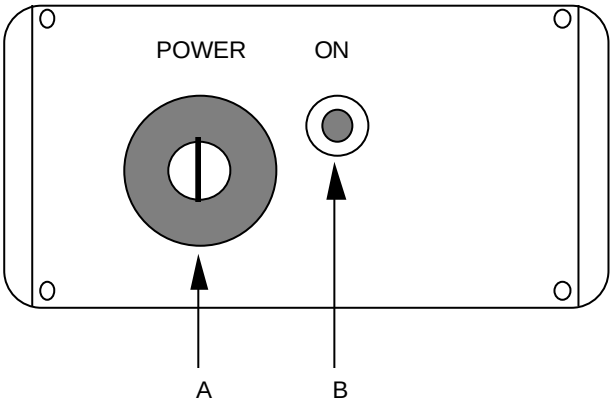


Figure 5: Front panel

A: Key switch. The key is removable when power is off
B: Power ON LED. Illuminated when power is turned on. Color: Green.

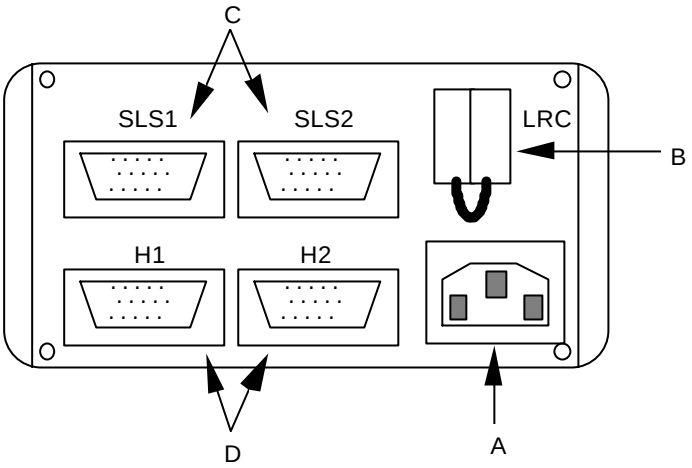


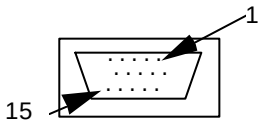
Figure 6: Rear panel

A Power receptacle

B Laser Remote Control, LRC connector Screw terminal with a jumper controlling the LASER ON signal to both SLS7000 1 and SLS7000 2.The lasers are on if power is on AND the jumper or a remote switch is closed.

C Two SLS7000 sensors connectors, SLS7000 1 and SLS7000 2. Female Socket connectors for easy connection of one or two SLS7000 sensors with DSUBmin connectors.

Front view, DSUB-15 pin, socket connector
SLS Powerbox 24
connectors SLS1 and SLS2



1 Receive data, RS232-C
9 Transmit data, RS232-C

3 CLOCK, SELCOM interface or RS422 Rx+
4 CLOCK-inv, SELCOM interface or RS422 Rx-
5 DATA, SELCOM interface or RS422 Tx+
6 DATA-inv, SELCOM interface or RS422 Tx-

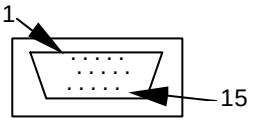
8 Invalid out-, (when analog interface is used)
12 Invalid out + , (when analog interface is used)
13 Analog out

11 Ground
14 Laser ON, (+24 VDC)
15 Power, (+24 VDC)

Figure 7: SLS7000 1 and SLS7000 2 connector female pin configuration

D Two output connectors, H1 and H2.Male Pin connectors with capacity to output all signals available from the SLS7000 sensor.

Front view, DSUB-15 pin, pin connector SLS Powerbox 24 connectors H1 and H2



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5 DATA, SELCOM interface or RS422 Tx+
6 DATA-inv, SELCOM interface or RS422 Tx-

8 Invalid out-, (when analog interface is used)
12 Invalid out + , (when analog interface is used)
13 Analog out

11 Ground

Figure 8: H1 and H2 connector male pin configuration

Technical specification:

Dimensions:

Length:	218.6 mm	(8.5 inches)
Height:	62.8 mm	(2.5 inches)
Width:	143.7 mm	(5.6 inches)
Weight:	1.4 kg	(3.1 lbs)

Environmental conditions:

Protection class: IP50 NEMA 1

Temperature:

Operating:	0-50 °C	(32-120°F)
Storage:	-30-70 °C	(-20-160°F)

Power requirements:
Input voltage: 110/230 VAC (± 10 %)
Line frequency: 50/60 Hz
Power consumption: 40 W (50 W peak at startup)

2.2.3 Video Camera

An optional video camera may be ordered with the sensor to facilitate exact operator positioning of the 10-micron laser spot on the work object.

Video parts:

- Sensor integrated video camera
- External camera controller with standard video output on BNC connector (specify video standard EIA or CCIR)
- Video lens f+12
- 110-240 Vac Power adaptor (Specify US or Europe connector type)

The video camera option is preferably ordered with the sensor but may be added as an update.

Video camera and camera controller come as a factory-tuned set and must be serviced and replaced as one part.

To avoid problems finding a suitable video monitor for displaying the video camera scene, it's important to specify the correct video signal type, EIA for North America, Japan and CCIR for Europe.

The latter also applies for the power adaptor that requires a specification for use in the USA or Europe.

The camera controller is delivered with its user settable control switches in the "automatic" position. These settings will for most applications provide a sufficient image quality. All accessible switches on the camera controller are free to change in order to enhance image quality.

To enhance image quality like contrast and definition of laser spot on scene it is also recommended to add lighting to the scene.

Depending on requirement, scene lighting can be accomplished with everything from an ordinary office table lamp to sophisticated light guide fibres. The main consideration when adding light is to avoid possible heating and thereby expansion and movement of the measurement object.

The sensor data will not be influenced by added light as such, although the possible heating of the sensor may cause initial drift until a stable sensor housing temperature is established.

3 Laser safety

3.1 Classification

Sensors in the SLS7000 series are classified Class ll (FDA), class 2 (IEC 825-1:1993)

Special precautions are only required to prevent continuous viewing of the direct beam. A momentary exposure, limited by the blinking reflex (t<0,25 sec), as would occur in accidental viewing situations, is not considered hazardous.

However, staring into the beam should be avoided and the laser beam should not be intentionally aimed at people.

3.2 Warning labels

The following labels are attached to the sensor:
Figure 9: Manufacturers serial number label (Valid for all languages)

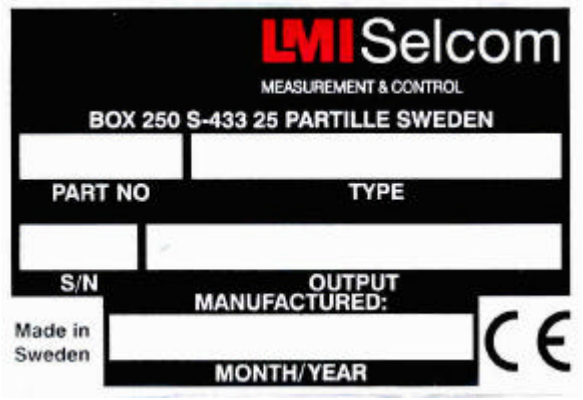


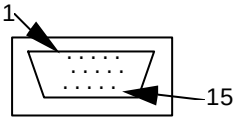
Figure 10: IEC - 825 (example English)

Aperture Label

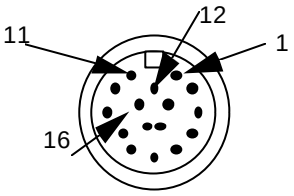
4 Installing

4.1 Pin configuration

DSUB-15 pin, pin connector



CONTACT series R2.5-16 pin, pin connector



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4 CLOCK-inv, SELCOM interface or RS422 Rx-
5 DATA, SELCOM interface or RS422 Tx+
6 DATA-inv, SELCOM interface or RS422 Tx-

8 Invalid out-, (when analog interface is used)
12 Invalid out+, (when analog interface is used)
13 Analog out

11 Ground
14 Laser ON, (+24 VDC)
15 Power, (+24 VDC)

Figure 11: 15 pin DSUB miniature, Male pin connector (3 rows) and 16 pin CONTACT series R2.5, male pin connector, front views.

Note: The DSUBmin connector meets IP50 (NEMA 1). The connector may require extra protection if mounted in a humid environment, although dust alone will not require any added precautions.
The CONTACT connector meets IP65 (NEMA 4) when connected with mating connector.

4.2 Cable requirements

4.2.1 Cable length

Interface	Pin number	Max cable length
RS 232	1, 9, 11	15m
RS 422 or Selcom serial	3, 4, 5, 6	100 m
Analog	11, 13	100 m (<7.5 Ω/signal lead)
Invalid	8, 12	100 m

4.2.2 Signal leads with demand for twisted pairs

Interface	Pin number
RxD - GND (RS232)	1, 11
TxD - GND (RS232)	9, 11
CLOCK - CLOCK-inverse	3, 4
DATA - DATA-inverse	5, 6
Rx+ - Rx- (RS422)	3, 4
Tx+ - Tx- (RS422)	5, 6

4.2.3 Signal leads without demand for twisted pairs

Signal lead	Pin number
Analog out (Current source)	13
Laser ON +24VDC (+5 - +32 VDC)	14
Invalid out+ (optocoupled)	12
Invalid out- (optocoupled)	8

4.2.4 Power supply leads

Main power. The power supply leads should be dimensioned so that the voltage between pin 15 (+24VDC) and pin 11 (GND) never falls below 18 VDC. For a 24 VDC power source this means that the total resistance in the power and ground leads must not exceed 15 ohms.
Laser ON (control input). Pin 14 must be held at +24 VDC (+5 - +32 VDC) to enable the laser.

4.2.5 Cable screening

The cable shall include a screen connected to a conductive connector housing in the “sensor end” of the cable.

4.3 Analog output

4.3.1 General considerations

The analog current output of the SLS7000 sensor is derived from the same high performance and accuracy digital distance data as available over the Selcom Serial, RS232 and RS422 interfaces.

The D/A conversion is made from a 12 bit's distance data value.

As a complement to the analog output, an "Invalid out" signal is available. The sensors are available in two versions **(factory set, not to be changed by the user!)** regarding the state of the analog output when data is considered "invalid":

"Hold latest valid" i.e. the analog output current is held at the latest valid D/A converted data value.

"Zero out on invalid" is only available with 4-20 mA output. The analog current output is set to 0 mA as long as data is considered invalid.

IMPORTANT: The transformation of the current output to engineering units (i.e. mm, inches etc.) in a control computer, PLC etc. requires the use of a "scale factor (SF_I)" that defines the relation between current output and engineering unit.

Sensor type	0-20 mA SF_i (mm/mA)	4-20 mA SF_i (mm/mA)
SLS7001/15	0,0512	0,064

It is NOT CORRECT and will lead to erroneous results if the measurement range is simply divided by the current range!!

If an absolute distance between the target and the sensor (or some other ref. Point) is to be computed, it is necessary to be aware of the fact that the fixed calibration point between the sensor and the current output is defined at the Stand-Off distance as being 10 mA for a 0-20 mA sensor and 12 mA for a 4-20 mA sensor.

4.4 Load conditions for analog and invalid outputs

4.4.1 Analog output load

The current output load resistance should not exceed 500 ohms. A separate return path to ground should be provided via pin 11 (GND). The total resistance in the analog out lead and the ground lead must not exceed 15 ohms.

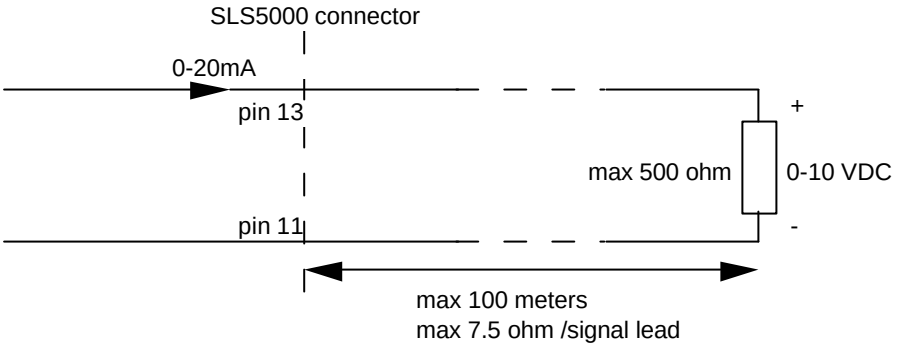


Figure 12: Example of connection:

Note:

We recommend the use of temperature stable resistors to reduce the effects of voltage variations due to resistance changes.

Always turn the power off before connecting or disconnecting the analog output load.

4.4.2 Optional noise filtering

Due to cable cross talk, the spectral characteristics of the analog current output, as measured over a 100 Ohm resistor, may have the following principal appearance:

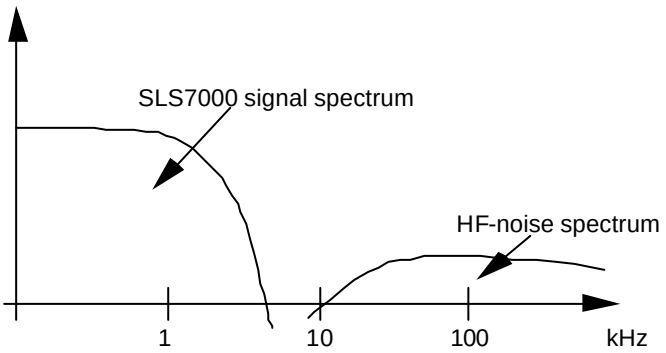


Figure 13: Illustration of spectrum

The analog output of the SLS7000 sensor mainly finds its use in low bandwidth, industrial measurement and control applications. The signal conversion equipment in such applications is normally band limited to low frequencies making the system insensitive to high frequency noise.

For some wide band applications like vibration analysis or when the signal is to be manually studied with an oscilloscope, the high frequency noise may be a problem. In these cases an anti-aliasing filter may be added between the load resistor and the registration equipment.

A simple but in most cases sufficient filter is shown below. The components as chosen will give an upper frequency limitation of 1.6 kHz. It is important that the filter and the registration equipment is connected with as short cabling as possible to avoid additional noise pick-up.

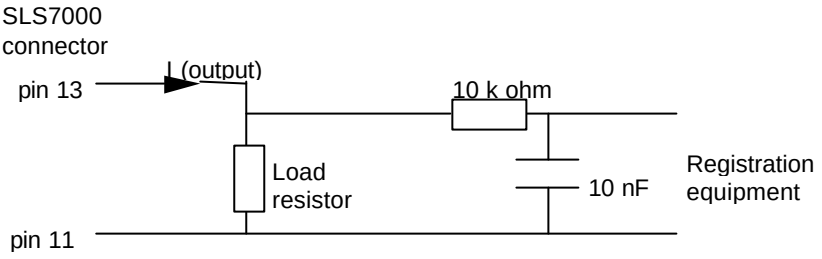


Figure 14: Example of filter

4.4.3 Alternative connections for valid output

The output transistor conducts as long as the measurement is valid.

Figure 15: Example of connection (current sink)

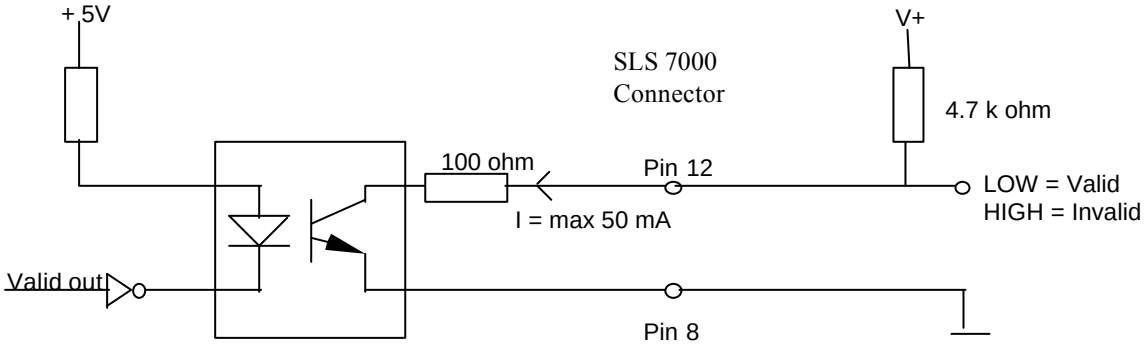
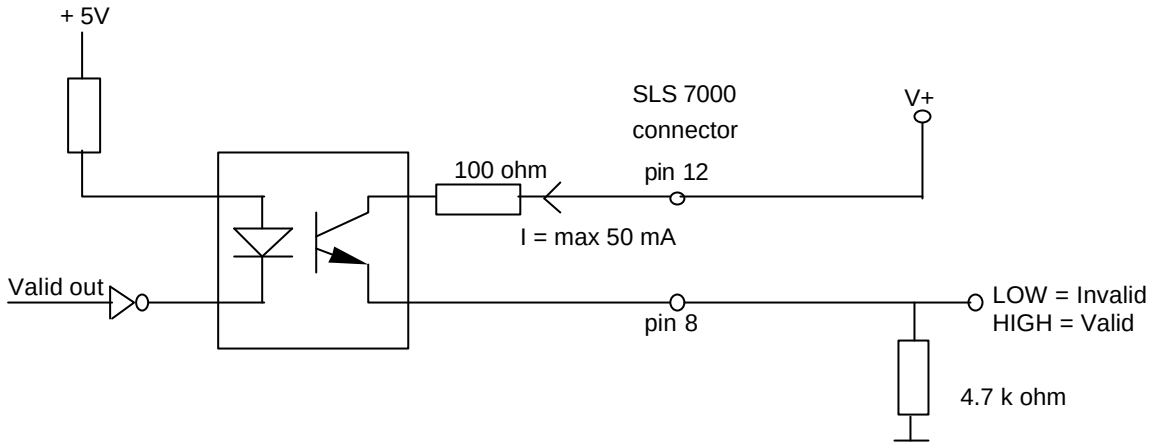


Figure 16: Example of connection (current source)



4.5 Mechanical mounting

4.5.1 Sensor head mounting

Due to the high resolution of the sensor, careful consideration must be paid to the mounting of the sensor head.

The way of mounting should be targeted at avoiding measurement errors due to:

- Thermal expansion and mechanical instability in the mounting fixture
- Mechanical tension in the sensor housing when tightening the mounting screws.
- Pick up of electro-magnetic noise and disturbances.

Normal considerations for precision measurement equipment should be sufficient for the overall fixture stability.

For the actual fitting of the sensor to a mounting surface, the flatness must be considered. If a sufficient flatness can't be guaranteed, it's recommended to use small diameter, precision washers to distance the sensor slightly from it's mounting surface.

If strong ground current/loops from welding equipment, electrical motors etc. can be expected in the sensors vicinity, it's recommended to mount the sensor electrically isolated from the mounting structure. This is also recommended when several sensors are mounted close to each other and powered from the same supply.

4.5.2 SLS-PPU mounting

Mounting of the SLS-PPU is less critical from mechanical strain considerations.

Care must of course be taken to avoid unnecessary cable bending and strain on connectors.

To isolate the SLS-PPU, the unit is delivered with special nylon washers that fit in the mounting holes. Use of the isolation washers is always recommended.

5 Technical specification

5.1 general

LASER SOURCE			**ENVIRONMENTAL**		
Laser type		GaAlAs	Operating temp.	C/F	0-50/32-122
Laser Class		II/2	Temp. fluctuation	% of mr/C	0,01
Max. output power	mW		Relative humidity	%	<90, non cond.
Wavelength	nm	675			
Laser life expectancy	hrs	100000			

ELECTRICAL			**PHYSICAL**		
Power supply	V_{DC}	+18 to +32 V	Dimensions (sensor head)	mm	120x95x40
Current draw	mA	< 500	Dimensions (SLS-PPU)	mm	135x105x50
In-rush current	A	1 A during 50 ms	Weight(sensor head)	g	750
Sampling rate	Hz	16000	Weight(SLS-PPU)	g	1000
Frequency response	Hz	2000	Cable length (Sensor head- SLS-PPU)	m	2
Detector type		PSD	Cable length (SLS-PPU)	m	2

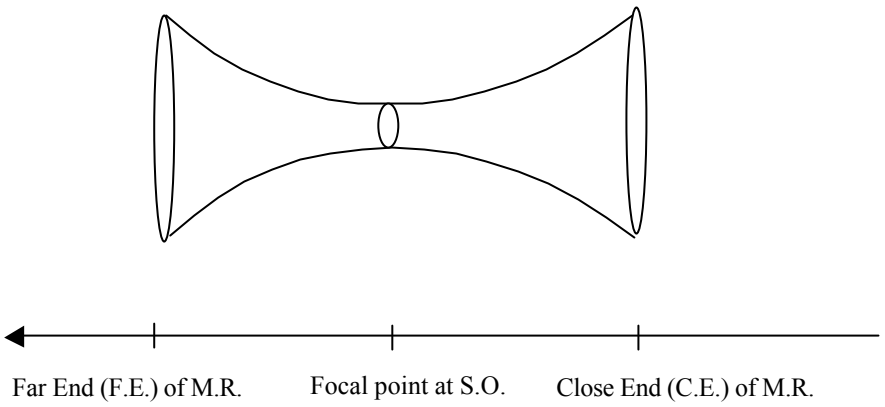
5.2 Performance specification

TYPE	M.R.	STAND OFF	RESOLUTION	LINEARITY	TRIANG. ANGLE
SLS7001/15	1	15	15,6nm-0,25um*	0,05 %of MR	86

* Depending on averaging and data type (analogue, RS232 etc)

5.3 Laser beam characteristics

Figure 17. Laser beam characteristics (principal)



Beam diameter at S.O.: 10 – 20 um

Beam diameter at S.O. +/- 0,45 mm: 70 - 90 um

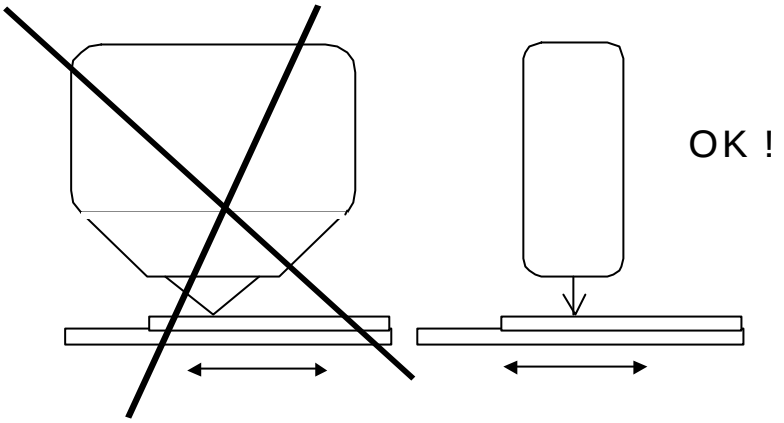
The beam diameter is specified to contain 90 % of the beam energy

6 Hints on correct use

Most precautions commonly mentioned when applying triangulation sensor also apply for the SLS7000.

Measurement of steps and detection of edges

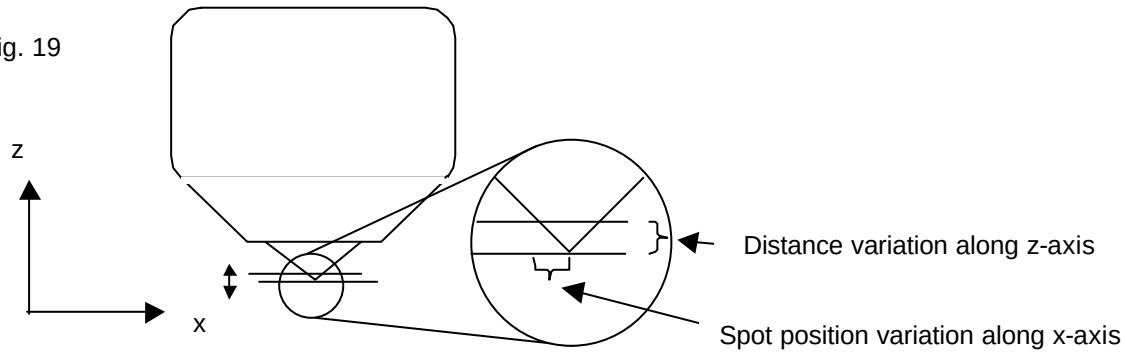
Fig. 18



To avoid “spot shadowing” and achieving best edge definition, orient the sensor triangulation plane in parallel with the step or edge !

“Beam walk” on targets with height differences

Fig. 19



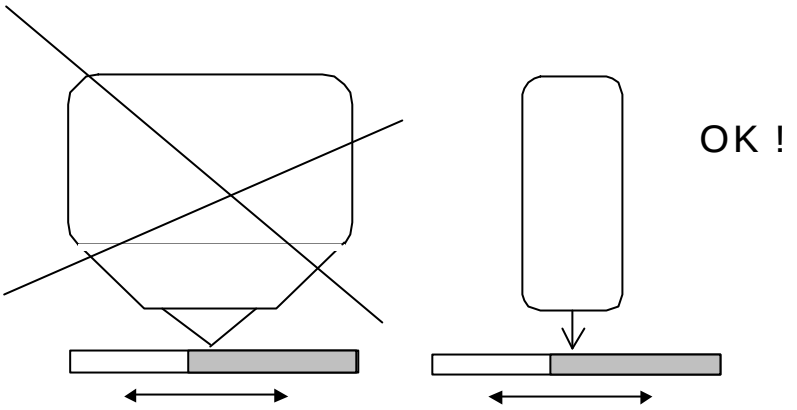
The SLS7000 is calibrated to give the target distance perpendicular to the sensor front (z-axis), whereas the laser beam is falling onto the surface under a steep angle.

As the sensor to target distance varies, the laser spot position in relation to the sensor will not only move along the z-axis but also along the x-axis.

This “beam walk” on the target surface will inevitably cause topographical distortion when mapping or scanning a surface.

Measurement across reflectivity or colour transitions

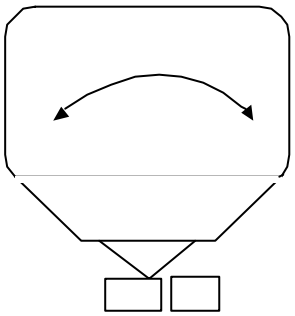
Fig. 20



To minimize spot centre of gravity shifts, orient the sensor triangulation plane in parallel with the transition !

Sensor alignment

Fig. 21



The sensor tilt in the triangulation plane may be optimised for best repeatability after sensor exchange, surface structure insensitivity etc. by control of a known step height difference and a fine pitched tilt adjustment.

Use precision, mirror polished, gauge blocks as target.

7 Communication interfaces

7.1 General

The SLS7000 is supplied with several serial communication alternatives.

The RS232 interface is always available over pins 1 and 9 in the sensor connector.

The main function of the RS232 interface is to facilitate internal sensor parameter set-up for production parameters as gain, laser power etc.

A sub-set of these parameters are also available for customer use via the “SELCAT” menu (ref. : 6.3 SLS-asynch-1, Protocol)

The RS232 Interface may also be used for low speed sensor data communication.

To facilitate data collection and presentation, several examples of free software for use on PC via simple com-port communication, is available from LMI Selcom. Please contact LMI Selcom or your local representative for more information.

For RS232 cabling refer to 4.2 Cable requirements

The Selcom Serial Interface (SSI)/RS422 is a four wire interface available over pins 3,4,5,6 on the sensor connector

The choice between SSI and RS422 interface is factory made and must be defined when ordering the sensor.

The SSI is a one way high speed (16 kHz) sensor distance data interface. For electrical and data format description refer to 6.2 Selcom Serial Interface.

The RS422 is a medium speed (1 kHz) full duplex communications interface. The command set is basically a sub-set of the RS232 command set. For a complete protocol description refer to 6.3 SLS-asynch-1, protocol.

7.2 Selcom Serial interface

16 bit serial synchronous interface, including 12 bit measurement data and 3 bit valid/invalid signal.

Updating frequency: 16 kHz

Balanced data output : D , D-inv., C, C-inv.

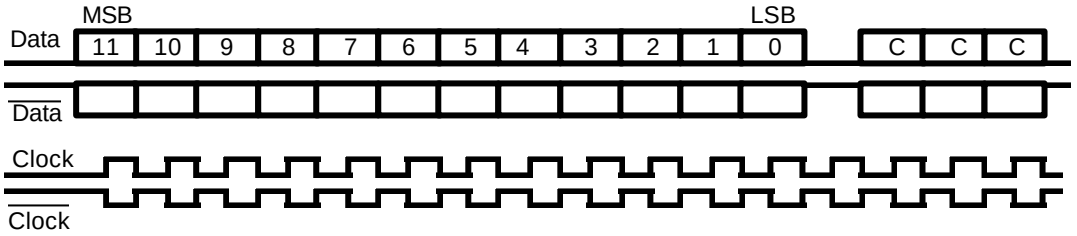


Figure 220: Data output format

Logical ”1”: C > 0.6 V + C-inv.
D > 0.6 V + D-inv.
Logical ”0”: C-inv. > 0.6 V + C
D-inv. > 0.6 V + D

Max. Load : (OH = Output High, OL = Output Low)
Voltage: U(OH) > 2.0 V
U(OL) < 0.8 V
Current: I(OH) > 40 mA
I(OL) < -40 mA

7.3 SLS-asynch-1, Protocol

General information

Baud rate	9600 baud	(RS-232)
	38400 baud	(RS-422)
Character length	8 LSBs	
Parity	None	
Start LSBs	1 LSB	
Stop LSBs	1 LSB	
HW handshake	None	
SW handshake	XON/XOFF	(RS-232, ASCII reply mode only)
Max update rate	50 Hz	(RS-232, ASCII reply mode)
	100 Hz	(RS-232, binary reply mode)
	1000 Hz	(RS-422)

The SLS7000 sensor always operates as a slave, i.e. it never initiates a data transfer itself. All data transfers must be requested by an external device, referred to in the rest of this document as the *master*. The master can communicate with the SLS7000 sensor either via RS-232 or RS-422. The RS-422 command set is a subset of the full RS-232 command set. RS-232 commands are always ASCII, whereas RS-422 commands are binary. The output from the SLS7000 may be either ASCII or binary over RS-232 but is always binary over RS-422.

Definitions

Distance Value	The reply differs with the measurement unit that is used. The actual number of fractional digits (in the case of millimeters or inches) depends on the sensors scale factor.
Measurement Validity	The reply gives the validity of the signal as a percentage of the last 100 samples
Laser Intensity	The reply gives the laser intensity as a percentage of the maximum. The maximum is calibrated when the sensor is manufactured. A command for reading the actual laser power in milliwatts exists in RS232, ASCII reply mode (see section Laser Intensity).
Sensor Temperature	The reply gives the temperature in degrees Celsius. It is measured inside the sensor.

Conventions

The following conventions are used in this document:

nnnnn	Groups of the letter **n** stand for integer numbers written with ASCII characters. The number of **n**'s indicate the maximum permitted number of characters. Fewer characters may be used.
Rrr.rrr	Groups of the letter **r** stand for real numbers (i.e. numbers with an integer part and a fractional part) written with ASCII characters. The number of **r**'s to the left of the decimal point indicate the maximum permitted number of characters for the integer part, and the number of **r**'s to the right of the decimal point indicate the maximum number of characters for the fractional part. Fewer characters may be used, and the decimal point may be omitted if it is not needed.
0xXX	The notation **0xXX** indicates a binary byte value. The two following characters are in hexadecimal notation. **NOTE:** This is *not* an ASCII representation. For example, if a byte value is given as 0x41, only one character (one byte) will be sent, in this case the character 'A', and *not* the four characters '0', 'x', '4', '1'. Where successive bytes refer to different types of data, they are distinguished by the notation **0xXX**, **0xYY** etc.
0xXXXX	The notation **0xXXXX** indicates a binary word value. It is transmitted as two characters (bytes) with the most significant byte first. Where successive words refer to different types of data, they are distinguished by using the notation **0xXXXX**, **0xYYYY** etc.

ASCII Commands and Replies (RS-232)
Command and Reply Structure

RS-232 commands and replies are structured as follows:
Every command sent from the master must be preceded by a ”dollar” character ($).
Every command sent from the master must be terminated by a ”greater than” character (>). This terminating character will be referred to as the *prompter* in the rest of this document.
There will be no output from the SLS7000 sensor until the prompter has been received.
Between the leading ”dollar” character and the prompter comes the actual command. It consists of a command character (always an uppercase letter) and possibly a numerical parameter, depending on the command. The commands belonging to the batch class described in section Batch Commands may be concatenated in a single command, so that there may be up to four command characters at the same time.
The SLS7000 sensor outputs a prompter as soon as it is ready to process commands after power on. No commands may be issued by the master until it has received this initial prompter.
Replies from the SLS7000 sensor always start with the command character and end with the prompter. In between there may be data, depending on the command. There is no initial ”dollar” character in the reply.
The master may not output a new command until it has received a prompter back from the SLS7000 sensor in response to the previous command.
Illegal commands, commands whose parameters are outside the legal range, and commands which contain more characters than the maximum (12 characters) will be rejected by the SLS7000 sensor.

Batch Commands

The ”Distance Value”, ”Measurement Validity”, ”Laser Intensity” and ”Probe Temperature” commands all take a parameter **nnnnn**, which determines how many values the SLS7000 sensor should transmit. The data transmitted as a result of such a command is referred to as a *batch* in the rest of this document. These four commands may also be concatenated into a single command. In this case they may appear in any order, but they must precede the **nnnnn** parameter. The parameter applies equally to all the data types in the command (i.e. it is not possible to ask for one number of distance values and another number of temperature values).

Distance Value:

Command:	**$Dnnnnn>**	(msm unit = LSBs)
Reply:	**Dnnnn>**	
	Drrr.rrr>	(msm unit = millimeters)
	Drr.rrrrr>	(msm unit = inches)

This command causes the SLS7000 sensor to transmit a number of distance values. The number of values is determined by the parameter **nnnnn**. The maximum value that can be used is 65535. A parameter value of 0 causes the SLS7000 sensor to transmit distance values continuously until it receives another batch command.
The reply to this command differs with the measurement unit that is used. The actual number of fractional digits (in the case of millimeters or inches) depends on the probe’s scale factor. The numbers shown here represent the maximum.

Measurement Validity (%)

Command:	**$Vnnnnn>**
Reply:	**Vnnn>**

The parameter **nnnnn** works the same as for the ”Distance Value” command.

Laser Intensity (percent of maximum)

Command: **$Innnnn>**
Reply: **Innn>**

The parameter **nnnnn** works the same as for the ”Distance Value” command.

Sensor Temperature (°C)

Command: **$Tnnnnn>**
Reply: **T+nn** / **T-nn**

The parameter **nnnnn** works the same as for the ”Distance Value” command.

Examples

Command: **$DITV200>**
Reply: **DnnnnVnnnInnnT+nn>DnnnnVnnnInnnT+nn>** (200 repetitions)

This command causes the SLS7000 sensor to send 200 groups of values, where each group contains one distance value, one validity value, one intensity value and one temperature value. The example shows LSBs as measurement unit.

Note:
Although the command letters were given in the order D, I, T, V in this example, the SLS7000 sensor always replies with the values ordered D, V, I, T.

Command: **$D0>**
Reply: **Dr.rr>Dr.rr>** …. (Repeated continuously)

This command causes the SLS7000 sensor to send distance values continuously, until a new command is received. The example shows millimeters or inches as measurement unit.

Single commands

All commands except the four described in section Batch Commands will only cause a single reply from the SLS7000 sensor. They cannot be concatenated but must be given individually.

Laser Intensity (milliwatts)

Command: **$W>**
Reply: **Wr.rr>**

Laser On / Off

Command: **$L1>** (laser on)
$L0> (laser off)
Reply: **L1>**
L0>

Set Averaging Factor / Filter Cutoff Frequency

Command: **$Annnn>**
Reply: **Annnn>** (**nnnn** same as in command)

The current SLS7000 sensor software employs a rolling average filter. In this case the parameter **nnnn** determines how many samples should be included in every average. Any number between 1 and 1024 may be given.

Set Output Rate For Batch Data

Command: **$Bnnn>**
Reply: **Bnnn>** (**nnn** same as in command)

This command makes it possible to control the rate at which output is produced by the SLS7000 sensor in response to a batch command. The parameter nnn is a divisor which is applied to the basic 100 Hz frequency used by the RS-232 communication routines. In ASCII reply mode the highest possible output rate is 50 Hz, so **nnn** may not be lower than 2. The limitation to three characters means that the highest legal value is 999, giving an output rate of about 0.1 Hz, or one value every 10 seconds.

NOTE: The averaging filtering and data rate output are independent processes. The data sent from the sensor at a rate defined by the $Bnnn> parameter samples from the stream of data that is output from the averaging filter. A small averaging factor (i.e. high bandwidth measurement) in combination with a large B parameter (i.e. low data rate out) may cause aliasing phenomenon's to occur in the data. The opposite settings (large averaging and small B parameter) may cause the same data to be sent out several times. It is therefore recommended to match averaging and B parameter reasonably well.

Synchronize (reset filter)

Command: **$S>**
Reply: **S>**

This command causes the SLS7000 sensor to restart its filtering cycle from scratch. It may be used to ensure that several probes are in sync with each other.

Set Nominal Value (for calibration)

Command:	**$Nnnnn>**	(measurement unit = LSBs)
	$Nrrr.rrr>	(measurement unit = millimeters)
	$Nrr.rrrrr>	(measurement unit = inches)
Reply:	**Nnnnn>**	(**nnnn** same as in command)
	Nrrr.rrr>	(**rrr.rrr** same as in command)
	Nrr.rrrrr>	(**rr.rrrrr** same as in command)

This command is used to set a nominal value to be used at a subsequent calibration (see section Calibrate).

Calibrate

Command:	**$C>**	
Reply:	**C1>**	(calibration was OK) (calibration failed)
	C0>	

The SLS7000 sensor can be calibrated against a reference if, for example, it is desired to measure thickness of an object. The reference object should be in place and its thickness should have been given to the probe with the ”Nominal Value” command before the calibration is started.

Example:

An SLS7000 sensor is set up to measure the thickness of steel plates (in millimeters). The plates rest on a flat surface while they are measured. A calibration piece with the known thickness of 50 mm is used. First, the Nominal Value command is given:
$N50.0>
The SLS7000 sensor replies:
N50.0>
Then the calibration piece is put in place, and the Calibration command is given:
$C>
The SLS7000 sensor replies:
C1> (presuming that the calibration was OK)
After this, the SLS7000 sensor will present the actual thickness in mm of every plate that passes.

Reset Calibration

Command:	**$R>**
Reply:	**R>**

This command resets the offsets calculated by a calibration to zero.

Parameter Setup

Command:	**$P>**
Reply:	**PWD>**

This command is used to enter a setup menu, where some of the SLS7000 sensor’s internal parameters can be modified. This is an interactive menu, which demands the use of an ANSI terminal (or a PC running an ANSI terminal emulation program). Before the setup menu is shown, the user must enter the password after the **PWD>** reply from the probe.

Command:	**$SELCAT>**

Parameter:	**Options:**	**Keyb:**

Measurement Units:	LSBs/Millimeters/Inches	Tab-key
Protocol Type:	ASCII/Binary	Tab-key
Interface:	Selcom/RS-422	Tab-key
Samples Per Average:	1 - 1024	Num. Keys + Enter
Valid threshold (%)	10 - 90	Num. Keys + Enter
Analog Output On Invalid:	Hold Latest Valid/Output Zero	Tab-key

F1 = Save And Exit	F1
F2 = Save Do Not Exit	F2
F3 = Exit Do Not Save	F3

Illegal commands

Command: **$Q>** (as an *example* of an illegal command)
Reply:

All commands, which are illegal, have parameters with values outside the legal range, or contain too many characters (more than 12) will be rejected by the SLS7000 sensor and cause the reply shown above.

Binary replies (RS-232)

The SLS7000 sensor can be set up to give binary replies over RS-232. The primary reason for using this mode would be to speed up the data transfers and to make the master's job easier in decoding the SLS7000 sensor's output. Only a subset of the commands described in section Conventions can be used with binary replies. For instance, it would be impossible or at least rather complicated to transmit a fractional value in binary mode.

Note:
Only the replies are binary. The commands sent by the master to the SLS7000 sensors are the same as in ASCII reply mode.

Reply structure

In binary mode the reply to each command has a leading identifier, which consists of one byte, but there is no trailing prompter. In the replies to batch commands only one identifier is output for the whole batch, i.e. no identifying byte is prefixed to each data item. This means that the master must keep a correct count of received bytes in order to decode data properly and to know when the next command can be sent. This is especially important in the batch commands where large amounts of data, with different types of data intermixed, may occur.

Batch Commands

The batch commands can be used in binary mode. If two or more commands are concatenated, the identifier bytes are ORed together in the reply to allow the master to check that the SLS7000 sensor understood the command correctly.

Distance Value

Command **$Dnnnnn>**
Reply: **0xE1 0xXXXX 0xYYYY 0xYYYY** … (repeated nnnnn times)

This command can be used *only* if the measurement unit is LSBs. The first binary word after the identifier **0xE1** is the parameter **nnnnn** in binary form.

Measurement Validity (%)

Command: **$Vnnnnn>**
Reply: **0xE2 0xXXXX 0xYY 0xYY** … (repeated nnnnn times)
The first binary word after the identifier **0xE2** is the parameter **nnnnn** in binary form.

Laser Intensity (percent of maximum)

Command: **$Innnnn>**
Reply: **0xE4 0xXXXX 0xYY 0xYY** ... (repeated nnnnn times)

The first binary word after the identifier **0xE4** is the parameter **nnnnn** in binary form.

Sensor Temperature (°C)

Command: **$Tnnnnn>**
Reply: **0xE8 0xXXXX 0xYY 0xYY** ... (repeated nnnnn times)

The first binary word after the identifier **0xE8** is the parameter **nnnnn** in binary form.

Examples

Command: **$DI100>**
Reply: **0xE5 0x0064 0xXXXX 0xYY 0xXXXX 0xYY**
(repeated 100 times)

This command requests 100 groups consisting of a distance and an intensity value. The identifier **0xE5** is the inclusive OR of **0xE1** (Distance) and **0xE4** (Intensity) and allows the master to check that the command was properly understood. **0x0064** is the data count, being the binary word equivalent to 100. After these items there will come 100 groups consisting of one 2-byte distance value (**0xXXXX**) and one 1-byte intensity value (**0xYY**).

Command: **$DVIT1>**
Reply: **0xEF 0x0001 0xXXXX 0xYY 0xZZ 0xTT**

This command requests one group of data containing all four possible items. The identifier **0xEF** is the inclusive OR of **0xE1** (Distance), **0xE2** (Validity), **0xE4** (Intensity) and **0xE8** (Temperature). **0x0001** is of course the data count (1), **0xXXXX** is the distance value, **0xYY** is the validity, **0xZZ** the intensity and **0xTT** the temperature.

Single Commands

Laser On / Off

Command:	**$L1>** (laser on)
	$L0> (laser off)
Reply:	**0x71** (laser on)
	0x70 (laser off)

Averaging Factor / Filter Cutoff Frequency

Command:	**$Annnn>**
Reply:	**0xA0 0xXXXX**

The first binary word after the identifier **0xA0** is the parameter **nnnn** in binary form.

Set Output Rate For Batch Data

Command:	**$Bnnn>**
Reply:	**0xB0 0xXX**

The first binary byte after the identifier **0xB0** is the parameter **nnn** in binary form. The parameter may be as low as 1 in binary reply mode, giving an output rate of 100 Hz.

NOTE: The averaging filtering and data rate output are independent processes. The data sent from the sensor at a rate defined by the $Bnnn> parameter samples from the stream of data that is output from the averaging filter. A small averaging factor (i.e. high bandwidth measurement) in combination with a large B parameter (i.e. low data rate out) may cause aliasing phenomenon's to occur in the data. The opposite settings (large averaging and small B parameter) may cause the same data to be sent out several times. It is therefore recommended to match averaging and B parameter reasonably well.

Synchronize (reset filter)

Command:	**$S>**
Reply:	**0x90**

Set Nominal Value (for calibration)

Command:	**$Nnnnn>** (measurement unit = LSBs)
Reply:	**0x80 0xXXXX**

This command can be used *only* if the measurement unit is LSBs. The first binary word after the identifier **0x80** is the parameter **nnnn** in binary form.

Calibrate

Command:	**$C>**	
Reply:	**0xC1**	(calibration was OK)
	0xC0	(calibration failed)

Reset Calibration

Command: **$R>**
Reply: **0xD0**

Illegal commands

Command: **$Q>** (as an *example* of an illegal command)
Reply: **0xFF**

Binary commands and replies (RS-422)

Both commands and replies sent over RS-422 are binary. The command set is basically a subset of the RS-232 ASCII command set, but there is also a special command for requesting a batch of distance values with single laser intensity and probe temperature values added at the end of the batch. This command has no counterpart in the RS-232 command set and is included for backward compatibility with a specific software version.

Command and Reply Structure

The RS-422 commands and replies are not structured in any special way. It is in the nature of binary communication that any byte value may occur as data, and therefore it is not possible to set aside certain values for exclusive use as prompters, command indicators etc. Instead, it is of *vital importance* that both the master and the SLS7000 sensor keeps a correct byte count in order to interpret commands and replies correctly.
The SLS7000 sensor will not output anything over the RS-422 lines on power up.

Batch Commands

If more two or more commands are concatenated, the identifier bytes are ORed together in the reply to allow the master to check that the SLS7000 sensor understood the command correctly.

Distance Value

Command: **0xE1 0xXXXX**
Reply: **0xE1 0xXXXX 0xYYYY 0xYYYY** ... (repeated 0xXXXX times)

This command will report measurement values in LSBs, and without any calibration offset applied. The command works even if a measurement unit other than LSBs has been entered in the setup. The first binary word after the command identifier **0xE1** is the number of data items to be transmitted in the batch. The maximum is 0xFFFF (65535 values) and the minimum is 0x0001 (1 value). If the parameter is 0x0000, data will be transmitted continuously until the next batch command is received.

Measurement Validity (%)

Command: **0xE2 0xXXXX**
Reply: **0xE2 0xXXXX 0xYY 0xYY** ... (repeated 0xXXXX times)

The parameter 0xXXXX works the same as for the ”Distance Value” command.

Laser Intensity (percent of maximum)

Command:	**0xE4 0xXXXX**
Reply:	**0xE4 0xXXXX 0xYY 0xYY** ... (repeated 0xXXXX times)

The parameter 0xXXXX works the same as for the ”Distance Value” command.

Sensor Temperature (°C)

Command:	**0xE8 0xXXXX**
Reply:	**0xE8 0xXXXX 0xYY 0xYY** ... (repeated 0xXXXX times)

The parameter 0xXXXX works the same as for the ”Distance Value” command.

Special Batch

Command:	**0xF0 0xXXXX**
Reply:	**0xF1 0xYYYY** .. (repeated 0xXXXX times) **0xZZ 0xTT**

This command requests a batch of 0xXXXX distance values followed by one laser intensity and one temperature value. Note that the reply identifier in this case is not identical to the command identifier. This is for backward compatibility reasons. A parameter value of 0x0000 cannot be used with this command and would in any case be useless (this would in effect be equivalent to the command 0xE1 0x0000).

Note : For compatibility, the count parameter is NOT included in the reply of this command.

Examples

Command:	**0xE3 0x0100**
Reply:	**0xE3 0x0100 0xXXXX 0xYY 0xXXXX 0xYY** (repeated 256 times)

This command requests 256 groups consisting of a distance and a validity value. The identifier **0xE3** is the inclusive OR of **0xE1** (Distance) and **0xE2** (Validity) and allows the master to check that the command was properly understood. **0x0100** is the data count, being the binary word equivalent to 256. After these items there will come 256 groups consisting of one 2-byte distance value (**0xXXXX**) and one 1-byte validity value (**0xYY**).

Command:	**0xF0 0x2710**
Reply:	**0xF1 0xXXXX** (repeated 10000 times) **0xYY 0xTT**

This command requests a batch of 10000 (0x2710) distance values followed by one laser intensity and one temperature value.

Single Commands

Laser On / Off

Command:	**0x71**	(laser on)
	0x70	(laser off)
Reply:	**0x71**	(laser on)
	0x70	(laser off)

Averaging Factor / Filter Cutoff Frequency

Command: **0xA0 0xXXXX**
Reply: **0xA0 0xXXXX**

Set Output Rate For Batch Data

Command: **0xB0 0xXXXX**
Reply: **0xB0 0xXXXX**

The first binary word after the command identifier **0xB0** is a divisor which is applied to the 16 kHz sampling frequency. It may take on any value between 0x0010 (16) and 0xFFFF (65535), inclusive. This gives output rates from 1000 Hz to 0.244 Hz (one value every 4 seconds).

Synchronize (reset filter)

Command: **0x90**
Reply: **0x90**

Illegal Commands

Command: **0x33** (as an *example* of an illegal command)
Reply: **0xFF**

8 Ordering and spare parts information

The list below covers a limited no. of items that may come in question as customer spare parts.

It is by no means a full scope of parts available or accessories. For more information contact LMI Selcom or your local representative.

Part Type	LMI Selcom art. No.
SLS7001/15 incl camera option (US ver.)	812330
Video camera excl. lens (US ver.) (retrofit or exchange by Selcom)	813086
Video camera lens f+12	813087
Video cable BNC/BNC 3 m	813088
SLS Power unit 24	808246
Interface cable;SLS PU to PC (RS232 and RS422), 3 m	812999
Interface cable; SLS PU to PC (RS 422), spec. length in order	813135